NASA SBIR/STTR Technologies

H10.02-8292 - Plume Velocimetry Diagnostic for Large Rocket Engines

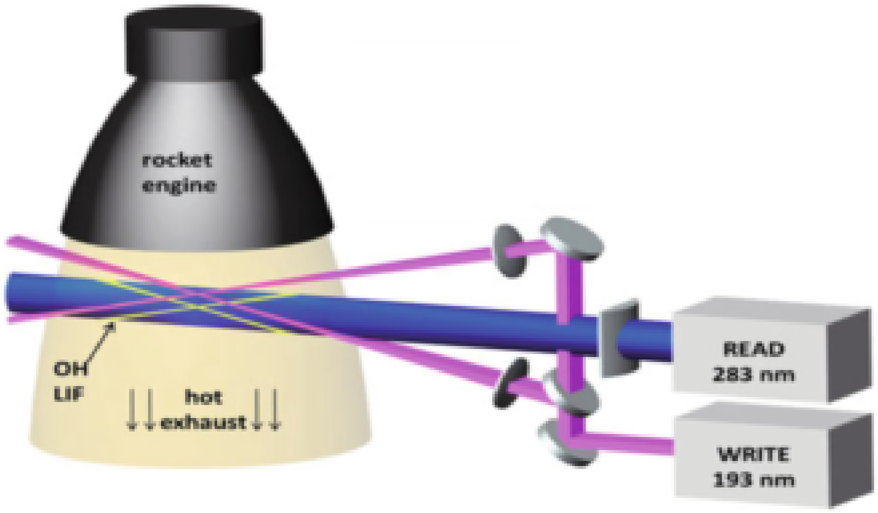
PI: Tom Jenkins

MetroLaser, Inc. - Laguna Hills, CA

Identification and Significance of Innovation

Measurements of plume properties are needed to validate computer models for the development of future engines. Velocity is of primary importance since it is directly related to thrust. Reliable methods for measuring velocity in large rocket plumes are currently lacking. Hydroxyl tagging velocimetry (HTV) is proposed as a solution, which involves tagging a line in the flow with OH molecules, and imaging that line after a short delay. Beams from a 193-nm laser dissociate water molecules, producing lines of excited state OH molecules. By crossing two beams, a non-ambiguous point is defined in space, which enables the measurement of displacement. The OH tag molecules are interrogated by laser-induced fluorescence using a second laser with a different wavelength. Velocity is then obtained from a time of flight measurement.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)



Technical Objectives and Work Plan

1. Define the engine test environment of a large booster engine, such as the RS-25, including temperature, pressure, species concentrations, and velocity range of the plume gases.
2. Estimate the effects of acoustic disturbances on HTV system hardware, including camera, beam delivery optics, read and write laser systems, and timing electronics. Determine a reasonable standoff distance for the optics.
3. Estimate the effects of plume turbulence on beam wander and beam fragmentation.
4. Estimate the level of attenuation by air of the 193-nm write beam.
5. Estimate the basic design parameters of a prototype HTV system, including focal length and f-number of imaging optics, laser pulse energies, layout of laser delivery optics, pulse generation scheme, and data acquisition and storage.
6. Estimate the useful lifetime of tagged OH molecules in the flow as limited either by chemistry or turbulent mixing, and use these estimates to predict signal-to-noise ratio.
7. Estimate the uncertainty in axial velocity for the basic HTV prototype design in the target engine plume given the expected signal-to-noise levels.

NASA Applications

NASA’s goals of returning humans to the Moon and sending humans to Mars and beyond present exciting challenges that will require significant advancements in propulsion technology. Accurate computer models can significantly reduce the cost of hardware development, but current models are limited by a lack of experimental data needed for validation. The proposed velocity diagnostic would provide crucial data that is needed for the development, qualification, and acceptance process of present and future computer models.

Non-NASA Applications

A successful velocity diagnostic for large rocket engine plumes would have broad application across the worldwide aerospace propulsion industry. Military applications include rockets, missiles, scramjets, and turbine engines. Commercial applications include the development of new turbofan designs that will require improved diagnostics for achieving increased efficiency.

Firm Contacts

Tom Jenkins
MetroLaser, Inc.
22941 Mill Creek Drive
Laguna Hills, CA, 92653-1215
PHONE: (949) 553-0688
FAX: (949) 553-0495

NON-PROPRIETARY DATA